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Project Title:
Estimation of seasonal dynamics of arid and semi-arid zone pasture productivity in Mongolian Gobi using NOAA/AVHRR data

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Executive Summary:

Purpose of project: Derivation of vegetation biomass from AVHRR-based vegetation health indices

First Year Achievements: During the first year, sites for filed experiments were selected, techniques of data collection was discussed and agreed upon. Preliminary comparative analysis of biomass and vegetation health indices was performed using historical data (1985-1997) at Tumentsogt Research Station located in eastern Mongolia 50 km from the capital. The goal of the comparison was to investigate potential of AVHRR data in the environment of Mongolia and to optimize biomass observational techniques in other ecosystems. During this year, we compared biomass anomaly with vegetation health (VT) estimates at Tumentsogt Research Station, exploring first, if satellite-based estimates of wet/dry/normal are coherent with ground classification and second, if both parameters have a similar trend during the growing season. From all dry years shown, 1986 had larger biomass reduction (20-40% or 60-80% below normal). Correspondingly, the VT during the same period was 30-40, which was up to 20 below the mean (50). The remaining dry years showed a similar match: below-mean VT and biomass. Two years in this category included a combination of dry spell and recovery to normal conditions. For example, in 1997 and 1992, biomass was low at the start (80%) following a very intensive drought (VT below 20) during the earlier months (50% rainfall reduction in June and July); later vegetation recovered to normal (100), matching with improvement in VT estimates. A slight overestimation of VT conditions in 1997 was not analyzed because weather records were not available. However, in 1997, as well as in the other three years, biomass and VT dynamics during the season were coherent.

Results indicate quite a good match between biomass and vegetation health indices both during the season and between the seasons. Preliminary results confirm the basic hypothesis and increase the feasibility that major goals in developing operational techniques for assessment of biomass production from operational environmental satellites will be achieved at the end.

Section I

A) Research Objectives:

Early drought detection and the assessment of its impact on pastures and diagnostics of biomass production are important tasks for Mongolia, which economy strongly depends on livestock production. Vast area and a lack of information on the distribution of grass availability due to spars biomass-observing and/or weather stations make it difficult to optimize nomadic livestock output in the Mongolian climate with frequent droughts. Therefore, the first year objectives were to investigate the application of a new method for early drought detection using AVHRR data and assessment of its impacts on wild/natural biomass in order to diagnose biomass production from polar-orbiting operational environmental satellites. The major objective for the first year was to locate and establish research stations in four major ecosystems with comprehensive and frequent observation for ground-truth measurements for simultaneous collection of AVHRR-based measurements of vegetation health indices.

B) Research Accomplishments:

Ecological Research Steppes: The original plan to develop the aforementioned methodology only for the desert steppe found to be less attractive for Mongolia as almost no pasture is available in these zones. In addition, we found that in order to accomplish the research objectives the methodology for the dynamic evaluation of pasture, applicable to Mongolia's needs will require simultaneous investigation of four steppe-areas: dry steppe (with limited, yet extremely important vegetation); typical steppe (natural grass); steppe zone (including partially cultivated area); and forest steppe. A reliable botanical research station was identified in each steppe zone where a botanical survey has been going on for almost 25 years (Figure 1).

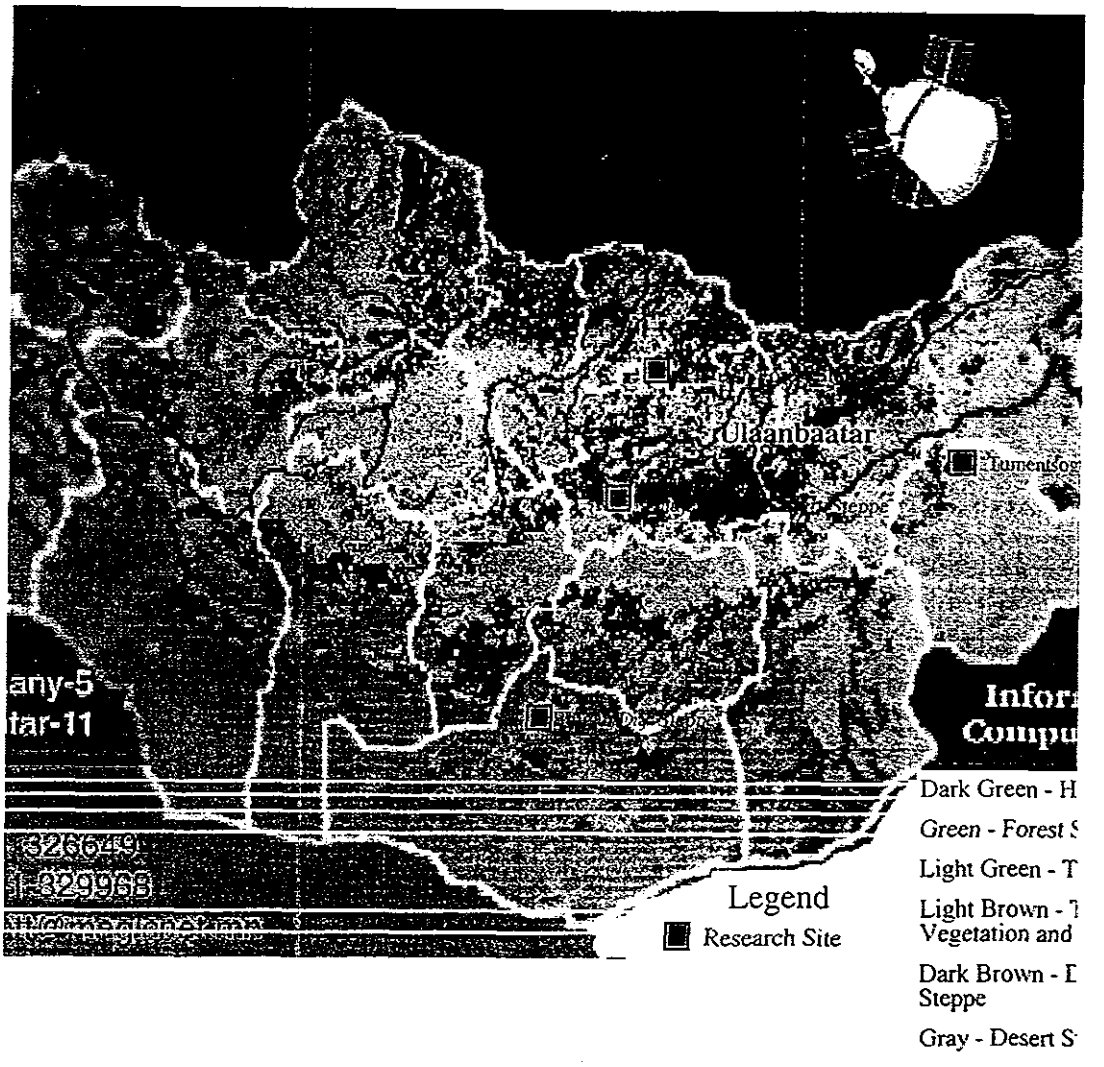

Figure 1:Location of botanical research stations in four steppes selected for this research

Following the first phase of this research and intensive review of historical data the following four research plots have been selected to collect ground-trooth data for this research (Figure 1):

1 Bulgan (dry steppe); 580 km from Ulaanbaatar, app. 13 hours drive under normal dry conditions);
2 Undjuul (typical steppe); 180 km; app. 4 hours drive;
3 Tumentsogt (steppe zone); 520 km; app. 12 hours drive;
4 Partizan (forest steppe); 53 km; app. 1.5 hours drive.

Driving time might even double in case of sudden rainfall and/or snow, as all roads are unpaved dirt roads (Figure 2).

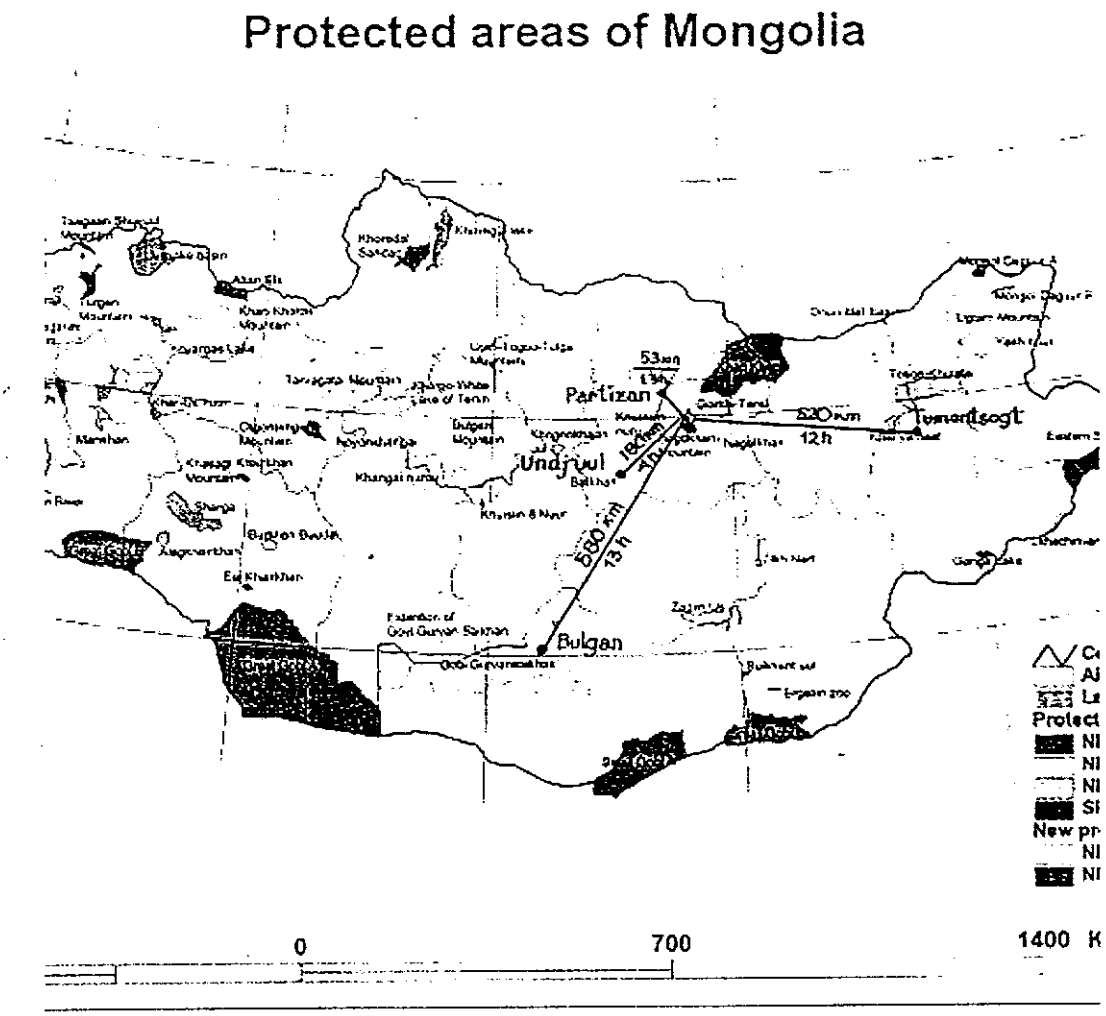

Figure 2 A map showing the location, distance and approximated driving time under normal weather conditions from Ulaan-Baatar for the selected research stations

During the first year, sites for filed experiments were selected, techniques of data collection was discussed and agreed upon and preliminary comparative analysis of biomass and vegetation health indices was performed using historical data (1985-1997) at Tumentsogt Research Station (located in eastern Mongolia 50 km from the capital). The goal for the comparison was to

investigate potential of AVHRR data to be correlated with one (or more) vegetation health indices as an indication for biomass stress.

Satellite data of Advanced Very High Resolution Radiometer (AVHRR) flown on NOAA polar-orbiting satellites in Global Vegetation Index (GVI) format were processed for Tumensogt steppe station. The GVI was produced by sampling the AVHRR-based 1-km daily radiances in: the visible (VIS, 0.58-0.68 Fm), near infrared (NIR, 0.72-1.1 Fm) infrared (IR, 10.3-11.3 and 11.5-12.5 Fm) spectral bands. The data were truncated to 8-bit precision, spatially sampled and mapped to a $(16\ km)^2$ grid. To minimize cloud effects, these maps were composite over a 7-day period by saving images for the day that had the largest NIR-VIS values. Further data processing included post-launch calibration of VIS and NIR calculation of the normalized difference vegetation index (NDVI=[NIR-VIS]/[NIR+VIS]) and conversion of the 10.3-11.3 Fm IR radiance to brightness temperature (BT), which was corrected for the non-linear behavior of the sensor. The algorithm for data processing was revised and adjusted to the Mongolian environment.

The radiances values (solar radiation reflected and emitted by the vegetation) measured by the AVHRR sensor reflect changes in leaf chlorophyll and moisture content and also thermal conditions of the vegetation canopy. These spectral radiances were converted to vegetation indices, which were used as proxies for estimation of the entire spectrum of vegetation health condition, from extreme stress to favorable. The three-channel algorithm consists of the comprehensive processing of the NDVI and BT, which includes removal of temporal high frequency noise, stratification of world ecosystems and detection of medium-to-low frequency fluctuations in vegetation conditions associated with weather variations. These steps were found useful and important in order to use AVHRR-derived indices as a proxy for temporal and spatial analysis and interpretation of weather-related vegetation condition and health.

Results show quite good match between biomass and vegetation health indices both during the season and between the seasons (Figure 3). These results emphasized that the hypothesis of this

proposal is correct and there is a very good chance that one of the major goals in developing operational techniques for assessment of biomass production from operational environmental satellites will be achieved at the end.

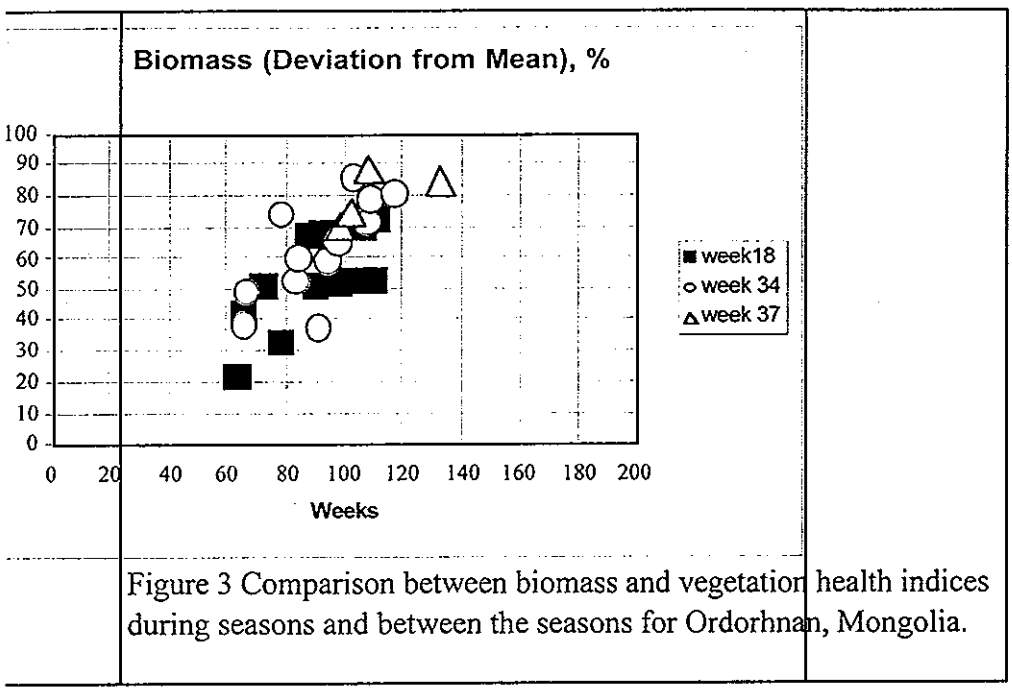

Figure 3 Comparison between biomass and vegetation health indices during seasons and between the seasons for Ordorhnan, Mongolia.

Finally, when the fund to build the scientific infrastructure of the Mongolian partners (both experimental and organizational) was already transferred in early March 2002 and the basic research equipment reached the research stations we are looking forward for the second year during which state of the art of biomass measurements (as ground truth measurements) will be performed in the selected field sites.

C) Scientific Impact of Collaboration:

During the kick off meeting in Ulaan Baatar, Mongolia (June 17-21,2001) we agreed upon two parallel routes: Developing of the methodology and adaptation of the RS indices to the Mongolian AVHRR data (research to be done in Israel & the US), and construct appropriate infra-structure in each of the four selected steppes. The scientific collaboration (vegetation cover data from Mongilia and satellite images by NOAA) yield the promising results as already mentioned above (see Research Accomplishments). The Mongolian team has already purchased

most of the necessary research equipment and items for the remote research steppes. It seems that we are all ready for the coming research season.

D) Description of Project Impact:

The preliminary results are yet premature for being used in large basin scale. However, following the coming research season, we hope to test our first year results for the Undjuul (typical steppe) and the Partizan (forest steppe). It is clear that the active AID-CDR projects established a new mood of scientific creation in the Institute of Botany that has long been dormant due to lack of resources.

E) Strengthening of Developing Country Institutions: Describe any project investments such as facilities, equipment or training that have been made. Summarize new research or managerial skills that have been acquired. Describe efforts to overcome institutional constraints.

The following equipments have already been purchased for the research team in Mongolia (March-April 2002):

Item	Quantity	Cost ($) [Exchange code: $ 1=T 1101.7)
Desktop (A SUS P4 1.7G)	1	1649
Leptop (DELL notebook C400 slim)	2	4980
Scanner (CanoSCan)	1	585
Fax (multipass-C75)	1	463
Printer (HP Desk jet 1125 color)	1	385
Printer (HP Laser Jet 1200)	1	430

Camping gear items have also been purchased for the field-work.

F) Future Work: What remains to be done? Is the project on schedule? Has the work plan been revised? If so, describe revision.

During the second year, the plans are to produce comprehensive measurements of biomass in the field experiments and update historical data. We are planning to start the field-work from the end of May. It would last until the end of September or mid October following the weather conditions in each steppe.

Ground-truth measurements: Botanical ground-data survey will be carried out in each of the following steppe zone: Bulgan (dry steppe); Undjuul (typical steppe); Tumentsogt (steppe zone); and Partizan (forest steppe).Ground-truth measurements of *vegetation species, density, height, reflected radiation, soil moisture, ground temperature and vegetation stress* must be measured during the growing season from May 1 to the end of September. It is clear that we should monitor the aforementioned parameters in existing botanical research stations where up to 25 years of information already exists. In addition to *biomass, vegetation density and chlorophyll content* will be measured. S*oil moisture* will be measured in 2 levels: surface 0-1 cm and subsurface 10-20 cm.

Intensive summer activities. Semi-arid climate of Mongolia imposes a very intensive and fast botanical evolution of vegetation growth and development during the growing season. Warm and wet weather in the second half of summer (from mid July) change the rate vegetation growth dramatically. In addition, grazing effects should be taken in consideration as well. Therefore, we concluded that weekly monitoring of both ground- and satellite-based vegetation parameters from May through October (6 months) will be sufficient for achieving the goals of this project.

Electronic data collection of the dynamic development of vegetation

The growing season vegetation dynamics will be monitored electronically in order to provide fast and reliable information to the IOB headquarter in Ulaanbaatar and later to the BGU. It will also guarantee unified botanical information from all research sites avoiding human interference. The electronic images will be double checked by manual sampling of vegetation and also measurements of the total biomass and the biomass for the 5 main plant species.

Eight plots (1 x 1 m each) will be monitored each week four selected sites. Digital photographic data will be taken in North-South and West-East directions. A white board (gridded at 1 x 1 cm) will be slid into the middle of each plot to serve as a reference for measuring vegetation height and density. The images will be downloaded on a portable PC and then transferred via telephone to the IOB and via the net to the BGU and later to NOAA. The PC will be served also as a data logger for the images and preliminary examination of the quality of the digital images. It will allow collection of ground-truth measurements in the RS laboratories in almost real time. In addition it will strengthen the research capacity of the Mongolian partners in the rural area far from Ulaanbaatar.

Temporal Remote Sensing resolution

Following the records obtained by the Mongolian botanists, the dynamic evolution of the vegetation in Mongolia is relatively fast due to sharp changes in weather condition. Therefore, for the development of the remote sensing methodology, it is suggested that ground-truth measurements will be obtained on a weekly basis. The two relatively nearby Ulaanbaatar botanical research stations can be weekly operated from Ulaanbaatar by the same equipment and technicians. However, the other two stations will require dedicated research equipment and gear, and permanent scientific technicians next to the stations for at least 6 months.

Section II

A) Managerial Issues:
Communication: Means of communication are improved mainly after the purchasing of private telephone line accompanied by a new Fax (new Fax number at the institute: **+976-11-451837**).
Money transfer: After few months of delay finally we managed the transfer the allocated money for Mongolia in March 2002. We hope that as the route has already been established it will remain open for future needs.

B) Budget: No budget changes have been made since the last revised budget approval in 2001 (See Management Report No. 1).

C) Special Concerns: None!

D) Collaboration, Travel, Training and Publications:

Collaboration: A close collaboration among all partners including our colleagues in Mongolia yield the firt vegetation health indices resulted from existing historical data. It sums up the first stage of preliminary assessment of our hypothesis and paved the road for the active research following our revised scientific objectives.

Travel:

- Training: Due to the political and military situation in the Middle East training of Mongolian researchers has not yet been accomplished. We all seek for better situation in the near future, which will also allow the exchange of scientific staff.
- Travel and visits:
- Dr. F. Kogan and Dr. E. Adar visited Dr. Chultem. Dugrajav and Dr. Shadar Tsooj, of the Institute of Botany, Mongolian Academy of Sciences (June 17-21,2001).
- Mr. R. Stark, a graduate research assistant in BGU spent ____ working with Dr. Kogan in Camp Spring, MD USA on derivation of pasture biomass in Mongolia from AVRHRR – Base vegetation health indices. In NOAA

Training: Training of adequate Mongolian student will be arranged for the coming academic year. Budget for student training has been reserved

Publications: In this initial stage of the research, no project publications have yet been published. A draft of a scientific paper entitled "Derivation of pasture biomass in Mongolia from AVHRR vegetation health indices" has been circulated among partners for comments and revision. It describes results obtained with historical data used for the preliminary development and assessment of the health vegetation indices.

E) Request for American Embassy Tel Aviv or A.I.D. Actions. Indicate how American Embassy Tel Aviv or AID/EG staff can assist in promoting project productivity.

The American Embassy staff in Tel Aviv including the AID/EG staff provided us with all requested necessary assistance. Thank you all for being so cooperative. INDEED!